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Jerry M. Conley, Director

SURVIVAL AND GROWTH OF SUMMER CHINOOK SALMON FED FIVE DIFFERENT DIETS

FINAL DRAFT

JANUARY 1983 FEED STUDY

by

John R. Thorpe
Fish Culturist

and

Bill Hutchinson
Hatchery Superintendent II

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ABSTRACT

A feed experiment was carried out during the 1981-1982 winter-rearing period at the McCall Summer Chinook Hatchery. Summer chinook fry from the 1981 brood year were reared under normal production rearing conditions and fed five different diets. The experiment was specifically designed to examine possible nutritional factors in preventing a recurring spring mortality. The survival, growth, and feed conversion achieved with each feed tested were compared.

All test groups displayed a high spring mortality during the experiment. Mortality ranged from 26.0% to 6.3% between the test groups. None of the groups fed the experimental feeds achieved a reduction in spring mortality.

After 90 days of test feeding, a closed-formula frozen-moist pellet (OP-4) achieved the highest percentage increase in average weight per fish of 109.4%.

The fish fed OP-4 achieved the lowest feed conversion (5.4) and the lowest cost per pound of fish produced ($2.65) over a 90 day comparison period.

Author:

John R. Thorpe
Fish Culturist

INTRODUCTION

The McCall Summer Chinook Hatchery commenced operations in the fall of 1979. Since that time, the hatchery staff has been involved in determining optimum rearing methods for the Mc Call system and South Fork of the Salmon River stock of summer chinook.

The 1981-82 feeding experiments at the Mc Call Hatchery were undertaken to investigate a possible solution to an unusual spring mortality occurring in 0+ fry, resulting in high (>1.0%/mo) mortality with an undefined etiology.

An unusual epizootic made its first appearance at the Mc Call Hatchery in 1980 with a loss of 15.4% during the month of May. The fry of brood year 1979 exhibited lethargic behavior, swimming on their sides, poor feeding response, all followed by death as the water temperature increased from the winter norm of 38 F (Wimer 1980). The individuals exhibiting those symptoms appeared to be average or above average in size rather than "pinheads." At that time, the syndrome was reported as being similar to clubbed gills "dropout" disease described in Wood (1974). Pathologists from Idaho, Montana, and Utah examined samples of moribund fish, but found no causative agent.

A similar outbreak occurred in the spring of 1981, with a 6.1% mortality during May. The brood year 1980 fry experienced an elevated mortality of .95%, 2.4%, and 6.1% during the months of March, April, and May. The spring mortality characterized by flashing, lethargy, hyperplasia of gills, no feeding response, a pinched in gut, and finally, death, was termed the "Spring Thing" for convenience of reference following the second recorded outbreak (Hutchinson 1981). Once again, samples of moribund and healthy fish were sent to pathologists in Idaho, Montana, and Washington for analysis. The "Spring Thing" was identified as nutritional gill disease and as bacterial gill disease (an atypical bacterial infection of the gills) by two separate pathologists. A feed change was recommended and the fry were placed on a double-vitamin pack Oregon Moist Pellet (OP-2) from Moore Clark Inc., rather than the standard Moore-Clark, Inc. OP- 2 pellet. The feed change did not result in a significant change in condition of the fry.

During 1981, the possibility of a nutritional deficiency being the cause of the "Spring Thing" was discussed. As a result, a feeding experiment was designed to test several feeds as alternatives to the OP-2 diet and evaluate their performance with regard to survival, growth, and dietary efficiency.

OBJECTIVES

The objective of this feeding experiment was to test the effect of feeding rations other than OP-2 in preventing the outbreak of "Spring Thing." The performance of the feeds were also to be evaluated with regard to growth, cost, and feed conversion.

TECHNIQUES USED

Rearing Conditions

The conditions maintained throughout the feeding experiment replicated standard production rearing conditions at the McCall Summer Chinook Hatchery. All lots were incubated in Heath upright incubators with eggs loaded at approximately 80 oz/tray. All test lots were set out at 1,600 ± 3 temperature units (T.U.) . Each vat was loaded with an average of 54,000 fry. Due to the small size of egg lots of summer chinook, it was necessary to combine the small early lots, lots 1-4, and portions of lots 5 and 6 to reach a size of approximately 64,000 for the OP-2 comparison lot. The other four test groups consisted of fry from only single egg takes. As a result of this combining, the OP-2 comparison lot contained fry which had been ponded for 20 to 73 days (1965 to 2018 T.U.) at the beginning of the evaluation period (15 February 1982) rather than 0 days as in the remainder of the test lots. Records of survival, growth, and feed consumption were kept for the total time that fish were reared in the vats. However, the values for growth rate and conversion were only compared for the first 90 days.

High mortalities in all lots late in the feed experiment required special action during May 1982. It was felt that reduction in loading density might reduce mortality. To reduce the loading density, all lots were transferred to the large outdoor rearing ponds in late May. That transfer terminated the experimental feeding program prior to the end of the spring mortality period.

All lots were initially set out in four foot wide vats with dropgates at 20 foot set for a water depth $_9$f 22.25 inches. The initial pond configuration allowed 129.8 ft of rearing space, with approximately 5.6 turnovers/hour. As the fish increased in size, pond volume was adjusted to maintain loading densities at less than the calculated Maximum Density Index (Klontz 1979), using a density index of 0.3, as recommended for chinook salmon. The Pond Loading Index was also calculated, but was not the critical value in setting pond loading densities.

Flows were adjusted to maintain water exchanges at greater than 3.5/hour throughout the test period. Water temperature averaged 37 F throughout the test period and dissolved oxygen ranged from 10.2 to 9.5 ppm.

All vats were brushed clean each afternoon and any mortalities removed at that time and recorded. Each vat had individual brushes and nets which were disinfected in a Benzalkonium Chloride solution after each use. Personnel disinfected their hands and forearms before cleaning any vat.

Diets Fed

Five different rations were fed to summer chinook salmon during the test period.

1. Bioproducts, Inc. (Warrenton, Oregon), Bio Diet Starter and Bio Diet, an intermediate-moisture (non-refrigerated soft-texture feed) ration was tested. Bio Diet was kept frozen prior to use to extend the shelf life as recommended by the manufacturer.

2. Clear Springs (Buhl, Idaho), trout feed, one of the commonly available dry feeds used within the state hatchery system, was tested. Clear Springs feed was stored at less than 50 F and for no longer than 90 days prior to feeding.

3. Moore-Clark Co., Inc. (La Conner, Washington), OP-2, the standard frozen moist pellet feed used by Idaho state hatcheries, was used as a control/comparison diet. OP-2 was kept frozen until the half-day ration was measured out.

4. Moore-Clark Co., Inc. (La Conner, Washington), OP-4, an optional frozen moist pellet containing an increased percentage of herring meal (71.4% more), and a variety of various components. The OP-4 ration was kept frozen until the half-day ration was measured out.

5. Rangen, Inc. (Buhl, Idaho), Rangen's Trout and Salmon Feed, a dry feed readily available to Idaho state hatcheries, was evaluated as an optional dry feed.

Feeding Techniques

During the evaluation period, various feeds were fed at levels and frequencies equal to or greater than manufacturer's recommendations. Feed levels were adjusted on the 15th and last day of each month. All feed was weighed out at 0800 and 1300 hours and fed by hand ten times per day. Individual feeding programs are described below:

1. Bioproducts

   The Bioproducts lot was fed #2 starter at 3.0% body weight/day for the first twenty-one days. Then the ration was altered to a 1:1 ratio of #2 and #3 starter for the next fifteen days. Number 3 feed was fed at 3.0% body weight/day for the remainder of the study period.

2. Clear Springs

   The fish were started on Clear Springs #1 feed at 6.0% body weight/day for five days. Then a 1:1 ratio of #1 and #2 feed at 6.0% body weight/day was fed for another five days. Fry feed #2 was fed at 6.0% body weight/day for the next four days. The feeding level was altered to 4.0% body weight/day on the 12th day and remained at that level for the remainder of the experiments. At 18 days, the feed size was changed to a 1:1 ratio of #2 and #3 feed. At day 37, the feed size was adjusted to #3 only. Feed was altered back to a 1:1 ratio of #2 and #3 feed at day 99 due to an inability of fish to accept the large difference in feed granule size between the #3 and #4 feed. The #4 feed was fed tempered with some #2 feed from day 112 up to ponding.

3. OP-2

   The fish were fed Oregon Starter Mash (OM-3) at 6.0 body weight/day for two days after initial ponding. Starter mash and 1/32" pellets were then combined in a 1:1 ratio and fed at 6.0% body weight/day for the following five days. After the initial seven day starting period, the fish were fed 1/32" pellets. The OP-2 control lot was a combination of six different lots. Care was taken to complete feeding of starter mash to each new lot in a separate vat prior to combining the lots to prevent exposure to older fish to fines. One portion, lot #4, 25,000 fish, was treated with terramycin (TM-50) to control an *Aeromonas sp*. septicemia prior to combining with the other lots. The OP-2 control group consisted of lots set out in vats between 4 December 1981 and 27 January 1982.

4. OP-4

Fish were fed OM-3 at 6.0 body weight/day for two days following initial ponding. OM-3 is the only starter mash available from Moore-Clark Co., Inc.. Feed mixed in a 1:1 ratio of OM-3 and OP-4 1/32" pellets was fed at 6.0% body weight/day for another five days. Fish were then placed on a diet of 1/32" pellet at a rate of 4.0% body weight/day for the remainder of the study.

5. Rangen's

Fish were fed Rangen's Swim-Up feed for two days at 4.0% body weight/day. The ration was then fed as a 1:1 mixture of Swim Up and #1 fry feed at 4.0% body weight/day for another five days. For the following 28 days, #1 fry feed alone was fed at 4.0% body weight/day. A 1:1 ratio #1 and #2 fry feed was fed at 4.0% body weight/day for 25 days. Then a feed mix of #2 and #3 fry in equal portions at the same feeding rate was fed for ten days. A ration of #3 fry feed only at the same 4.0% feeding level was fed for the remainder of the study.

Growth and Survival Records

During the entire study, the lots were sampled on the 15th and last day of each month in the same manner as for all production lots at the Mc Call Hatchery. Pound counts (number of fish/pound) were determined on the 15th and last day of the month to use in setting feed levels and monitoring growth. Due to extremely high mortality in the later part of the study, only data from the first 90 days of rearing has been utilized to evaluate growth and determine feed conversion. A comparison of Table 1 and Table 2 values for mortality and pounds produced indicates the problems of trying to calculate growth and feed conversion in the presence of extremely high mortality.

Survival was determined by removing and counting daily mortality from each vat. The population size of each lot was adjusted from mortality records on the 15th and last day of each month.

Total weight of each lot was determined both when transferring fish from incubators to vats, and when transferring fish from vats to outside ponds at the end of the feed study. At the time of final ponding outside, a large discrepancy (8-25% of final) between estimated numbers and actual numbers was discovered in all lots except the OP-2 lot. The OP-2 lot had been total weighed several weeks after initial ponding as part of the lot consolidation

Table 1. Growth, feed conversion, and mortality records for summer chinook fry fed five different diets for 90 days.

Diet	4 of Fish at Start	t of Fish after 90 Days	Mortality (4)	Size at Start(fish/lb)	Size after 90 Days(fish/lb)	Pounds at Start	Pounds after 90 Days	Weight Gained 90 Days	Pounds of Feed Fed	Conversion lbs. fed/ lbs. gained	Feed Cost Dollars per lb.	Cost per lb. of Fish Produced	% Increase In Average Weight Per fish
Bioproducts	52,513	50,849	1,664 (3.2)	1,241.0	711.3	48.5	71.5	23.0	199.8	8.7	$.568	$ 4.93	74.5
Clear Springs	49,098	47,678	1,420 (2.9)	1,131.0	640.6	54.0	74.4	20.4	237.8	11.7	$.285	$ 3.32	76.5
OP-2	63,945	59,303	4,642 (7.3)	1,064.0	959.8	59.2	61.8	2.6	251.8	98.9	$.380	$ 36.80	10.9
OP-4	50,014	48,422	1,592 (3.2)	1,147.0	547.8	47.3	80.4	41.1	222.4	5.4	$.490	$ 2.65	109.4
Rangen	53,979	52,409	1,570 (2.9)	1,219.0	812.6	50.1	64.5	14.4	223.2	15.5	$.300	$ 4.65	50.0

Table 2. Final growth, feed conversion, and mortality records for summer chinook fry fed five different diets during the experiment.

Diet	# of Fish at Start	# of Fish at Ponding	Mortality (%)	Size at Start(fish/lb)	Size at Ponding(fish/lb)	Pounds at Start	Pounds at Ponding	Weight Gained	Pounds of Feed Fed	Conversion lbs. fed/ lbs. gained
Bioproducts	52,513	45,057	7,456 (14.2)	1,241.0	656.0	48.5	67.6	19.1	247.2	12.9
Clear Springs	49,098	36,344	12,754 (26.0)	1,131.0	684.0	54.0	51.8	-2:2	387.0	Negative Conversion
OP-2	63,945	54,165	9,780 (15.2)	1,064.0	812.0	59.2	65.3	6.1	291.8	47.8
OP-4	50,014	48,857	3,157 (6.3)	1,147.0	474.0	47.3	98.8	51.5	256.1	5.0
Rangen	53,979	51,016	2,963	1,219.0	665.0	50.1	76.8	26.7	263.2	9.9

procedure. A decision was made to accept the final ponding figures for all lots and adjust those numbers back using the recorded mortality data. Those corrected starting population figures were used to calculate growth and values for feed conversion.

FINDINGS

Survival

All lots had similar patterns of mortality during the first 12 weeks of rearing (Fig. 1). Mortality was in the 100-200/week range for the first four-to-six weeks of growth, followed by a declining mortality level during the 6-to-12 week period. The OP-2 lot mortality became elevated somewhat earlier, possibly due to the inclusion of older fish (3-to-10 weeks of age) at start date in the combined lot.

Elevated mortality levels were recorded in all lots during the latter part of the vat-rearing period. A comparison of mortality to age in weeks after initial ponding shows that elevated mortalities were not directly related to age (Fig. 1). That is, the rise in mortality did not occur at the same age in each observed group. When mortality was plotted against calendar week (Fig. 2), the outbreak of "Spring Thing" was seen to appear over less than a three-week period in May in four of the test groups, although age of those lots varies at least five weeks. In comparison, the OP-2 lot, containing a broad age structure, contracted "Spring Thing" approximately one month earlier (prior to any water temperature increase). During the first week in May, the water temperature started to rise, and the average weekly temperature rose from the winter average of 37 F up to 43 F through the end of the month (Fig. 2). As the temperature increased, the typical "Spring Thing" characteristics were encountered. The elevated mortalities occurred first in the oldest lots within the May time frame. Although the OP-4 and Rangen's lots did not contract the "Spring Thing" until nearly three weeks after the water warming trend began, the same elevated mortalities and other "Spring Thing" symptoms did occur. None of the test feeds were found to either entirely prevent "Spring Thing" or significantly reduce the loss due to the syndrome.

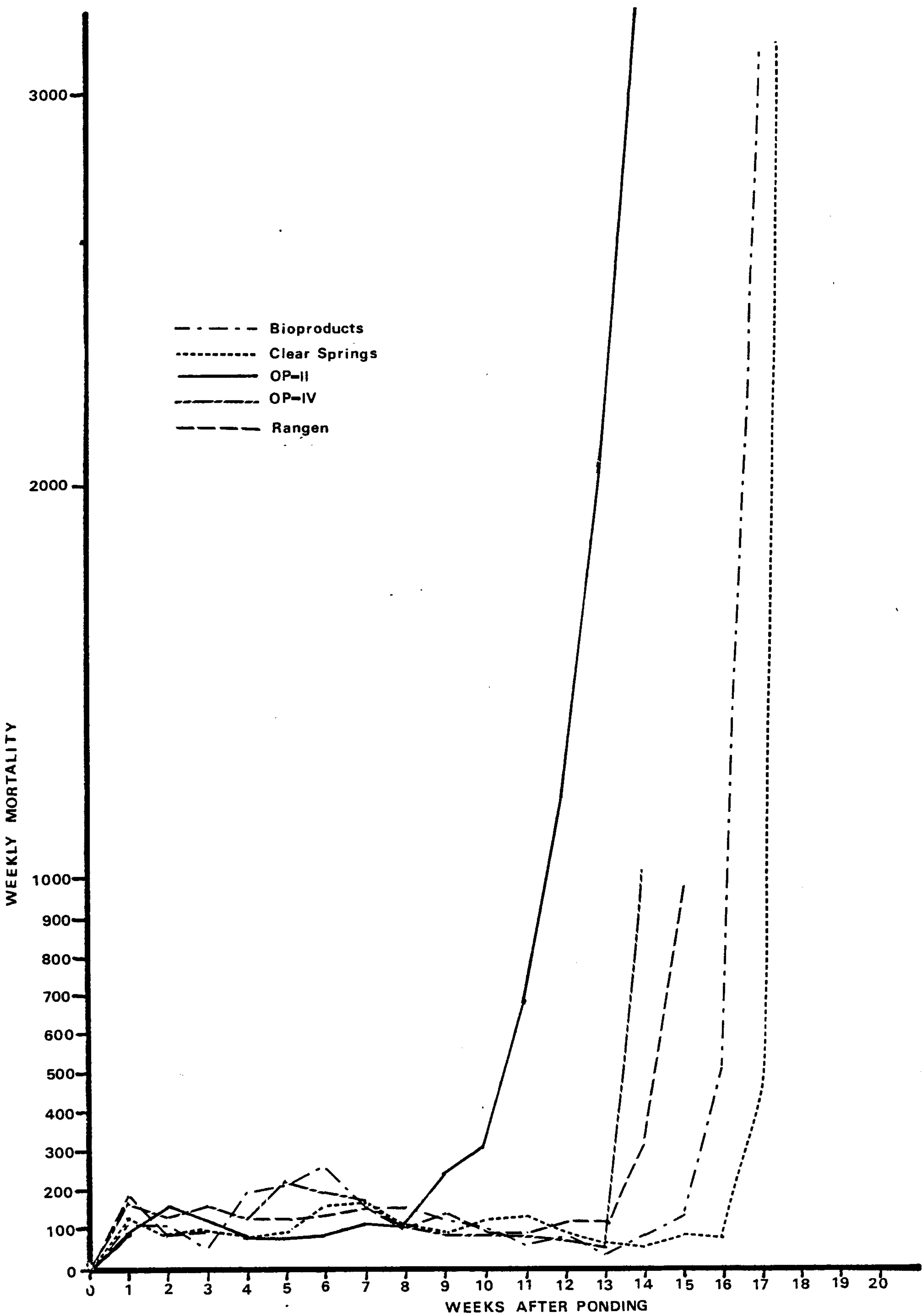

Figure 1. Weekly mortalities compared by age in weeks from initial ponding until transfer to outside ponds.

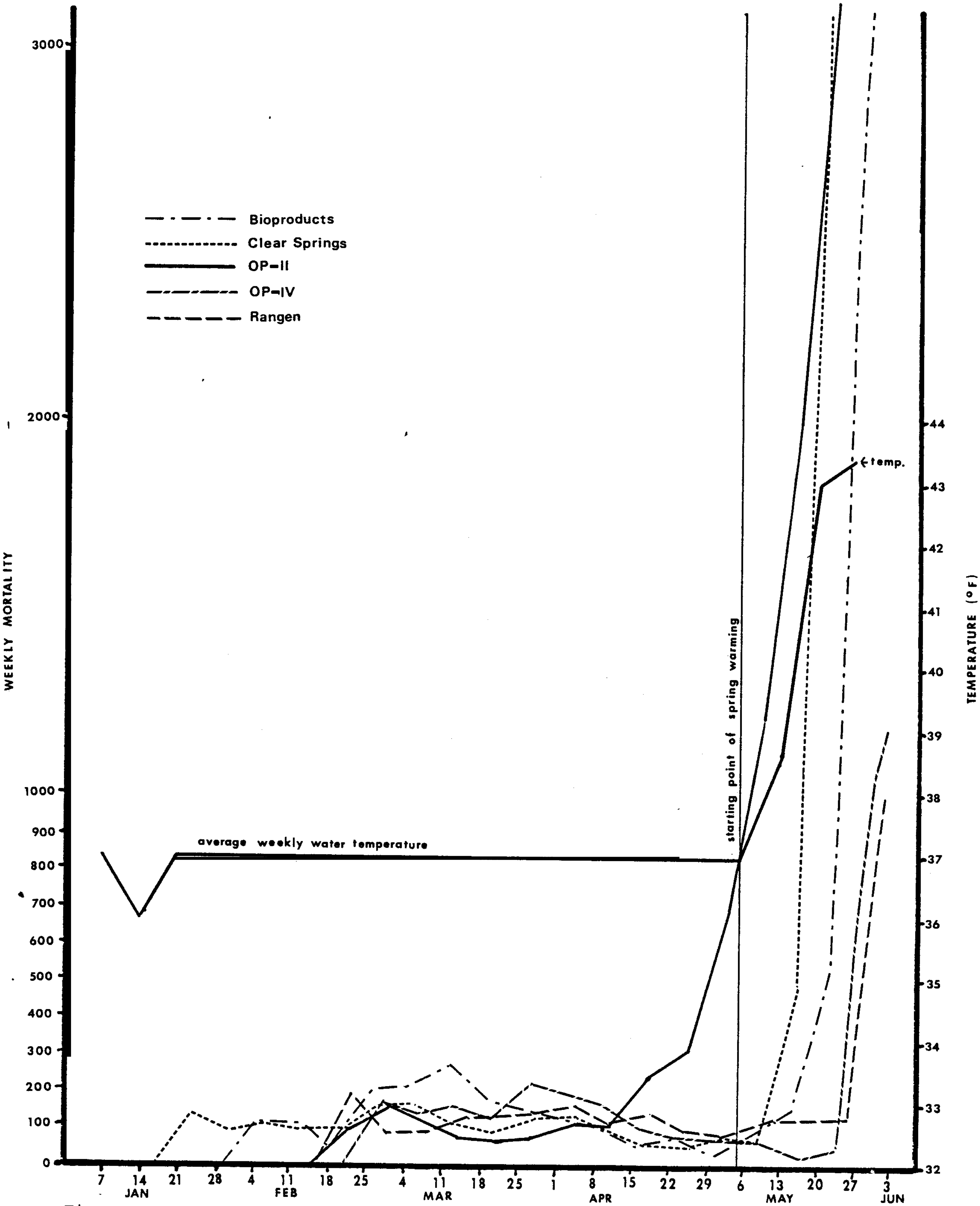

Figure 2. Weekly mortalities occurring from January to June 1982 and the average weekly water temperature during that period.

Growth

The growth rates achieved with five separate rations were compared during the feed experiment. The study was terminated for evaluation of growth at 90 days due the outbreak of "Spring Thing" and the ensuing poor feeding behavior. At the end of the 90 day evaluation period, a comparison of percent gain in weight/fish showed OP-4 to yield the highest gain (109.4%) and OP-2 the least gain (10.9%) (Table 1). Growth rates were compared for the entire period of experimental feeding in Figure 3. The OP-4 lot exhibited growth similar to other lots up to the 90-day point. After 90 days, while the Bio products, Clear Springs, Rangen's, and OP-2 lots showed similar growth, the OP-4 lot growth rate accelerated (Fig. 3). When growths of different lots (in fish/pound) were compared over the calendar year rather than chronological age, a period of virtually no growth was seen during the month of March for all lots except the OP-4 lot (Fig. 4).

Conversion

Final feed conversion values for the 90-day evaluation period were compared (Table 1). The best conversion rate was obtained with OP-4 feed (5.41 lbs fed/lb gained). That rate was considerably better (38% lower) than the conversion rate of the next best feed, Bio products. A determination of the cost per pound of fish produced during the study period indicated that OP-4 was the most cost effective of test feeds at $2.65/pound of fish produced (Table 1).

DISCUSSION

The original intent in undertaking the feed experiment was to test varied feeds as possible deterrents to the "Spring Thing" syndrome, particularly the high mortality experienced. Despite the fact that all lots exhibited high mortality late in the test period, a variety of information was still provided for consideration.

When a comparison of weekly mortality by calendar week of rearing was plotted, a very close succession of "Spring Thing" to spring water warming in all but one lot was apparent. None of the test feed lots, Bio products, Clear Springs, OP-4, and Rangen's, exhibited elevated mortality prior to the water-warming period. The OP-2 control lot had some mortality increase prior to water warming.

The early appearance of high mortality in the OP-2 may indicate that all lots could have broken with the disease earlier than they did, had they not received a different feed. Unfortunately, all other lots did contract the "Spring Thing" which indicates that none of the feeds were able to block the occurrence.

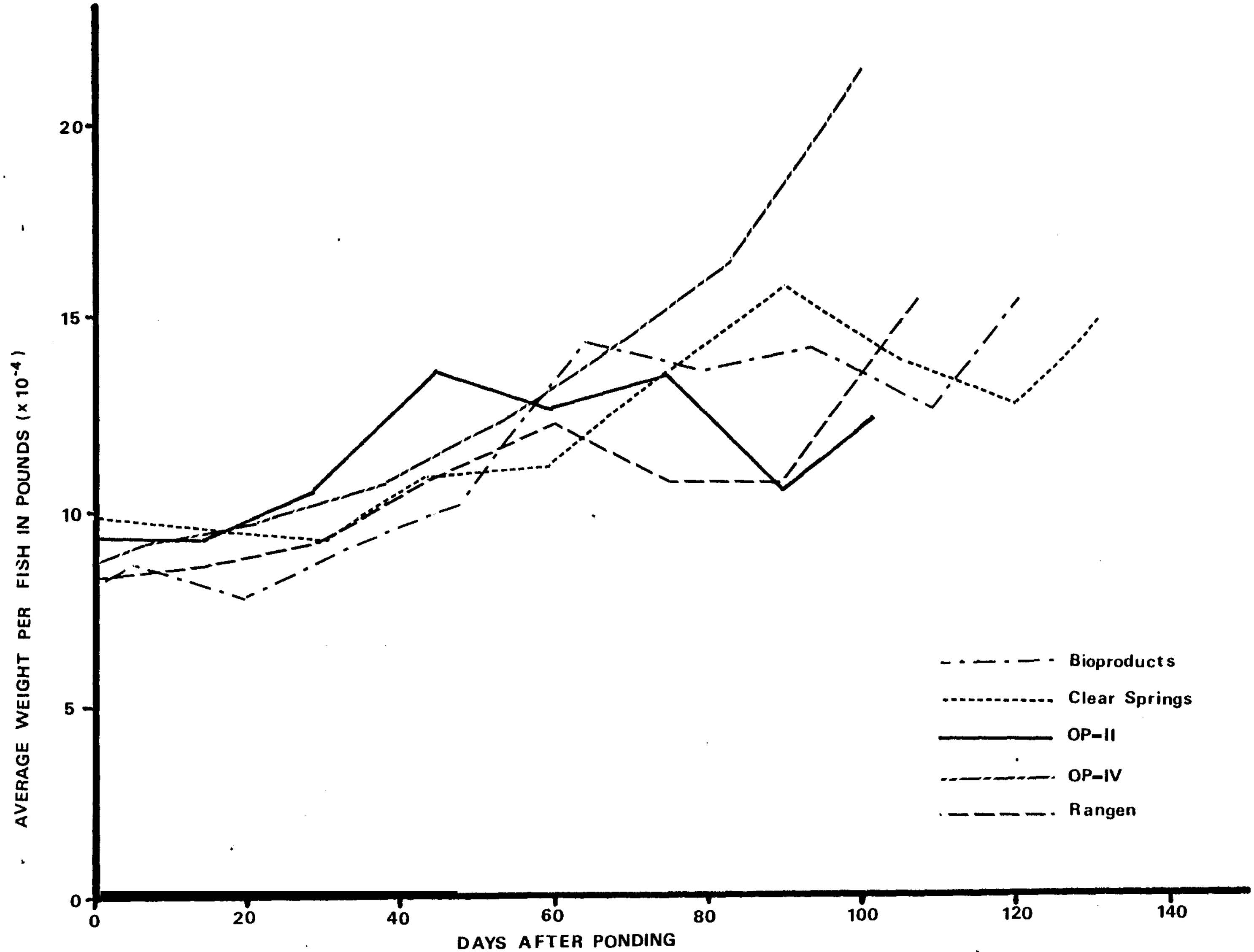

Figure 3. Average weight of fish in pounds from initial ponding until transfer to outside ponds.

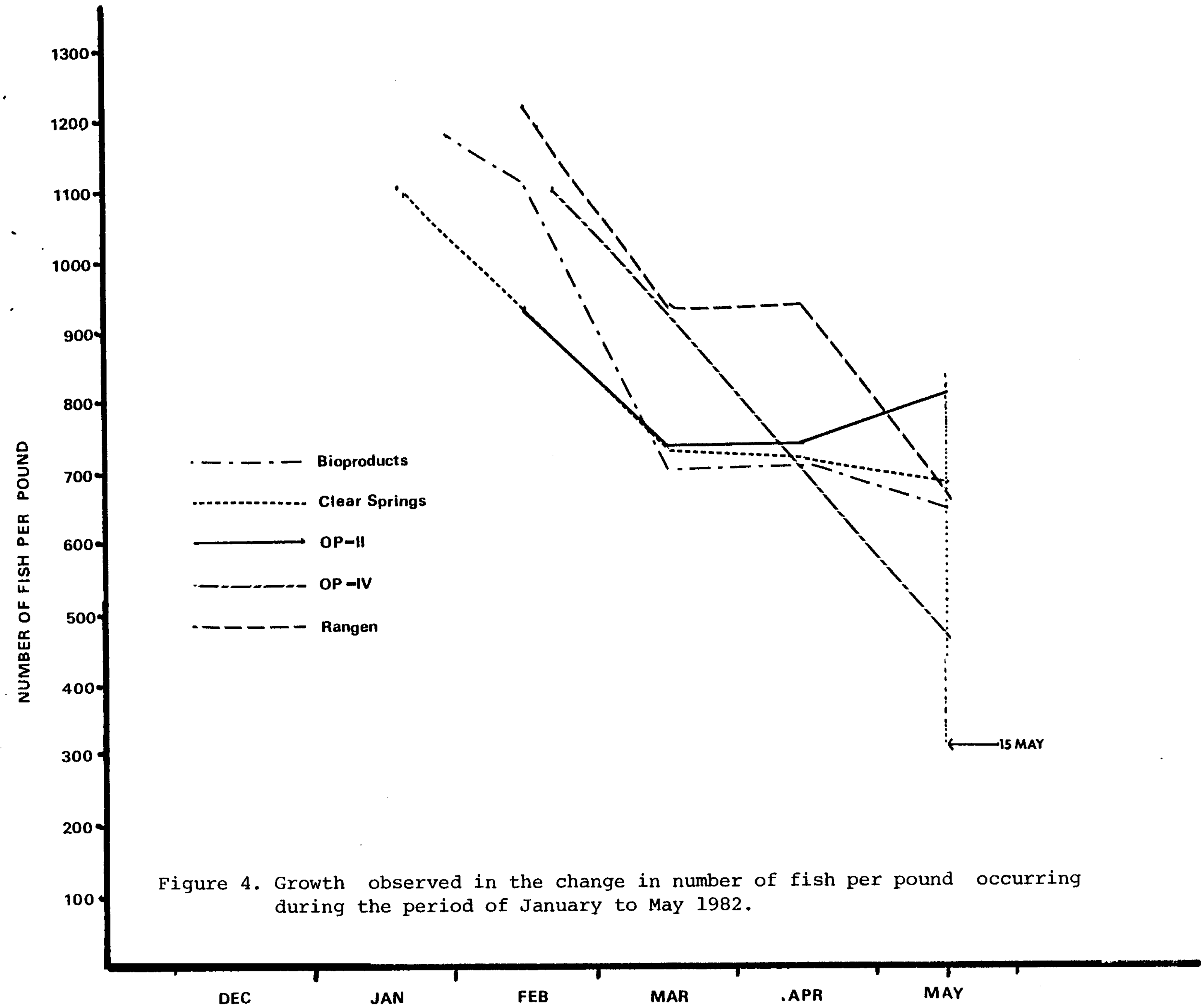

Figure 4. Growth observed in the change in number of fish per pound occurring during the period of January to May 1982.

An alternative consideration with regard to the earlier mortality in the OP-2 lot concerns a possible secondary disease in that lot. The summer chinook egg take number four, which numbered 25,462 (the largest single portion of the OP-2 control lot), set out on 31 December 1981, displayed some increased mortality in January prior to being combined in the OP-2 control group. Samples were taken from egg lot #4 and it was determined that an *Aeromonas* sp. septicemia was present. The lot was treated with TM-50 for two weeks in an attempt to alleviate the problem. Although no dramatic improvement was observed, it was determined that the lot was healthy enough to be combined in the OP-2 control lot. The *Aeromonas* sp. organisms may have still been present throughout the rearing period, but certainly did not result in any elevated mortality prior to April. Therefore, a possibility exists that the increase in weekly mortality in the OP-2 lot occurring in April may have been connected to a prior bacterial disease.

When the weekly mortality plots are compared, it can be seen that the rate of increase in mortality for the OP-2 lot prior to the early May water warming is not typical of "Spring Thing" outbreaks observed during this study. The cause of that variation was not determined during the study. The variable size and age among the groups combined for the OP-2 lot, as well as the appearance of a bacterial infection early in rearing in one group all are factors for consideration.

It was of particular interest to note that in all test groups the "Spring Thing" mortalities were not "pinheads" or monstrosities. The "Spring Thing" losses were physically well developed, as large or larger than the average-size fish in the vat and exhibited no outward signs of disease until immediately prior to losing equilibrium and floating to the tail screen. The fish lost in all groups had been feeding throughout the rearing cycle and growing normally, but were still unable to experience the spring warming without dying.

The failure of any of the feeds to prevent the outbreak of "Spring Thing" made the results particularly frustrating. It is still unknown what steps could be necessary to prevent this occurrence at the McCall Hatchery. The relationship of the rise in the water temperature in the spring to increased mortality can be clearly observed, but still provides no solution to the problem. Further research into solutions to the "Spring Thing" mortality is definitely required to reduce the massive losses occurring during such a short period of the rearing cycle.

The growth in fry during the winter months at the McCall Hatchery has always been quite slow. During the feed experiment, the water temperature was 40 F during the first part of December 1981, and then declined, as is normal. The average weekly rearing temperature through the feed experiment until 6 May 1982 was only 37 F. Although growth rates were not spectacular, there was a steady increase in size during the feed experiment (Fig. 3). The overall affect of rearing fry for long periods at low temperature is not completely understood. It has been well demonstrated that growth rates and feed level requirements decrease with water temperature (Brett et al 1969). Other physiological changes occurring have not been clearly outlined. The problem that has become apparent for the third consecutive year at Mc Call is that an increase in mortality is associated with an increase in water temperature. Whether or not the inability to respond to a change in water temperature without large mortality is due to some nutritional deficiency remains unanswered at this time. Although muscular development and length certainly indicated that feed ingested was converted into physical growth, the inability to survive changes in the environment indicates a possible failure in some part of physiological development.

The performance of each feed was examined with regard to fish growth and feed conversion. It has been generally accepted at Idaho state hatcheries that the OP-2 ration is the best for growth of Pacific salmon, particularly in cold water. After evaluating the performance of five different feeds during the study period; the performance of the OP-2 lot is of interest.

Rather than performing well among the feeds tested, the OP-2 feed resulted in the lowest growth rate, 10.9%. As an interesting comparison, the highest increase in average weight/fish was obtained with a feed manufactured by the same firm, but with a different formulation (OP-4). The OP-4 feed achieved the best conversion of 5.4 pounds of feed fed per pound of growth, which also gave the lowest cost per pound ($2.65). Also, the fish reared on OP-4 were the largest at ponding, although being reared the shortest period of time. An examination of pounds of feed fed/pounds gained shows that although test feeds, Bio products, Clear Springs, OP-4, and Rangen's, had conversion values from 5.41 to 15.5. The OP-2 control lot was extremely inefficient at a conversion of 98.9. Why one of the feeds in a test should perform so differently was of particular concern after the feed experiment. Although none of the chinook fry fed voraciously at 37 F, they all appeared to feed adequately and in similar manner. From the observation of feeding, it was assumed that all feeds were equally palatable. The question of palatability and actual consumption of adequate amounts of feed has been a question in recent studies (Lemm and Hendrix 1981; Fairgrieve, personal communication). In this study, all lots seemed to feed at generally the same rate. The extremely poor growth observed on OP-2 may, in fact, be due to some unidentified secondary disease as previously discussed in relationship to the early rise in mortality in the OP-2 lot. The presence of some low-grade infection could very well have altered the efficiency with which the OP-2 lot converted ingested energy into physical growth.

The lack of concrete evidence in any particular analysis of the results indicates that further research is needed to determine an optimum feed for the growth of chinook fry in the extremely low water temperature at McCall. Rearing test lots through the "Spring Thing" outbreak and on through the reduction in mortality occurring several weeks later as described by Wimer (1980) and Hutchinson (1981) may provide much more conclusive results with regard to survival and growth.

RECOMMENDATIONS

1. Conduct another feeding experiment to determine if the results obtained can be repeated to verify validity of the first study.

2. Rear the test lots on experimental feeds through cessation of the "Spring Thing" to clarify performance of each test feed with regard to survival.

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